The SZ technique could also reveal other vital statistics of the cosmos. Besides galaxies and glowing gas, clusters must contain even larger amounts of invisible "dark matter" to generate the gravity that holds the gas in place. "These clusters are kind of a garbage can which should contain the universal mix," says Carlstrom. If so, comparing a cluster's SZ shadow, which reveals how much ordinary matter it contains, with its total mass should reveal the cosmic ratio of ordinary to dark matter. Because cosmologists can use other measurements to calculate how much ordinary matter must have been forged in the big bang, they can parlay that ratio into the grand total of all matter in the cosmos.

But perhaps the field's greatest ambition is to use the SZ effect to measure not just the expansion rate, but how it has changed over billions of years. Observations based on exploding stars called type Ia supernovae have suggested that the expansion is actually speeding up, an indication that the common gravitational attraction of all matter in the universe is being overwhelmed by a mysterious repulsion. Distant clusters like those found by the Chicago group could eventually check the supernova results. Astronomers need better x-ray pictures of those far-off clusters, however, to extract precise Hubble constants from them.

And those pictures should be on the way. The U.S. Chandra satellite and the European XMM satellite, to fly within the next year, should ride to the rescue with much more sensitive x-ray detectors and spectrometers. "It'll be a revolution when the new x-ray satellites are really able to do those SZ images justice," says Myers. —JAMES GLANZ

CONSERVATION BIOLOGY

Lynx and Biologists Try to Recover After Disastrous Start

An effort to bring lynx back to Colorado is mired in controversy after five animals starved to death earlier this year

The distress call grew louder as Tanya Shenk snowshoed across drifts high in the Rocky Mountains last February. Shenk, a wildlife biologist for the state of Colorado, was in no hurry: The signal from the radio collar meant the victim was dead, perhaps killed by a predator. But when Shenk finally found the lynx curled under a spruce in Rio Grande National Forest, she realized to her horror that the emaciated beast, its telltale tufts of black hair shooting from the tips of its ears, had starved to death.

Similar scenes have played out four more times, including once last month, unleashing a torrent of criticism over a $1.4 million program to bring the dwindling Canada lynx back to Colorado. News of the starved animals has outraged critics, some of whom maintain the effort was doomed from the start: Even before the first lynx were flown in from Canada late last year, analyses had suggested that the animal's main winter prey, the snowshoe hare, was in perilously short supply. And some wildlife biologists worry that the furor over the Colorado program will provide ammunition to critics of other wildlife reintroduction programs around the country.

Scientists at the Colorado Division of Wildlife (CDOW) regret the starvation deaths but defend the reintroduction, which they claim may be their best shot at bringing the lynx back to Colorado. CDOW biologists cite a biological imperative to their timetable: Lynx in Canada are booming, so the population—this year, at least—could stand to lose the few dozen individuals shipped stateside. Some observers applaud the effort. Bringing back species like the lynx "is going to take a level of risk that none of us are really comfortable with," says the U.S. Forest Service's Bill Ruediger, endangered species program leader for the Northern Rockies. "I give them credit for doing it."

Other experts disagree, contending that individual animals should not suffer to such a degree for the sake of a species. Death and the struggle for survival in unfamiliar terrain go hand in hand: Managers expect up to half the animals in any given carnivore reintroduction program to die, felled by other predators or hit by cars after ranging far from release points. "We certainly expect them to have a high mortality rate," says Richard Reading, co-chair of Colorado's Lynx and Wolverine Advisory Team (LWAT) and director of conservation biology at the Denver Zoological Foundation. "But what you don't expect is starvation." "Without the right habitat and enough food source," adds Scott Mills, a lynx researcher at the University of Montana, Missoula, "reintroduction just becomes a death sentence."

All systems go? This lynx is one of a few dozen from Canada struggling for survival in Colorado.

CREDIT: CDOW

The lynx as a species managed to stave off one death sentence a quarter-century ago, when fur trappers hunted the animal nearly to extinction in the lower 48 states. A furtive creature about twice the size of a housecat, the lynx once ranged from northern Canada and Alaska to southern Colorado, but now only about 500 remain south of the Canadian border. Only once before have wildlife biologists attempted to bolster lynx numbers in North America, when 83 cats from the Yukon Territory were released in New York's Adirondack mountains in the late 1980s. The program failed miserably: Most lynx were killed by cars, and few if any survivors or their offspring are believed to be around today, says carnivore biologist John Weaver of the Wildlife Conservation Society.

Since the last confirmed sighting in Colorado in 1973, CDOW biologists have tried everything from baited traps to cameras mounted deep in the woods to spot any lynx lurking in the Rockies, without success. Deeming the effort futile, CDOW director John Mumma and several staff biologists concluded during a rafting trip in 1997 that the lynx deserved a shot at reestablishing itself in the southernmost fringe of its historic range, says Gene Bryne, the recovery team's lead biologist.

In late 1997, CDOW managers decided they had to act fast if they wished to run their own show. The U.S. Fish and Wildlife Service (FWS) at the time had begun considering a petition to list the lynx as threatened with extinction in the lower 48 states; a ruling is expected later this year. If FWS opts for extending federal protection to the lynx, it would call the shots on how and where to do so. "We had a short window of opportunity," says Bryne. "This was the last chance for the state of Colorado to reintroduce lynx."

A biological clock was also ticking. Lynx and snowshoe hare populations go through 10-year cycles of boom and bust. When hares are depleted, lynx begin starving—until hares rebound and the lynx follow suit. Lynx in Canada were cresting, so

the Colorado team could gain permission to import some for a reintroduction. Wait any longer, Bryne says, and lynx numbers would plummet—and Canadian officials would never send lynx stateside. "If Colorado would have come to us in a couple of years, we probably would have said no," says Harvey Jessup of Yukon's Department of Renewable Resources. "We don't encourage trapping when the lynx population crashes."

Before bringing in lynx, however, the Colorado team set out to determine which regions had enough snowshoe hares to support the cat. The failed Adirondacks effort offered few lessons, aside from the obvious need to release lynx far from any highways, says Bryne. Thus the CDOW scientists were starting mainly from scratch. "The lower 48 has always been considered a fringe area for lynx, so there's not a lot of data available," says Terry Root, an FWS biologist in Cody, Wyoming. The bottom line, says recovery team leader Rick Kahn, a terrestrial biologist, is that "there wasn't a cookbook that anyone could open and say, 'Here's a recipe' " for a reintroduction program.

Dinner is served. A scarcity of snowshoe hares may have led to lynx deaths.

Rather than mount a laborious and expensive census that could take years, CDOW biologists in summer 1998 counted pellets of hare scat at randomly chosen sites in 11 Colorado habitats. Using a well-known formula developed by Charles Krebs, a zoologist at the University of British Columbia, the CDOW team extrapolated from the scat to snowshoe hare density. Their findings, presented to the LWAT on 4 September, pointed to the San Juan Mountains as the most promising home for lynx, offering about 1.4 hares per hectare—almost three times the minimum density thought necessary to sustain the cat.

Later that month, LWAT member Kim Poole, a lynx researcher at Timberland Consultants in Nelson, British Columbia, used an updated equation from Krebs to calculate that the San Juan Mountains had only about 0.7 hares per hectare, a shade above the 0.5 hare minimum. Deeming that the lynx would find enough to eat, the Colorado Wildlife Commission approved the program that November. But Poole, after an e-mail exchange with Krebs, learned that the updated equation still overestimated hare density. Krebs devised a version that takes into account Colorado's patchy rocky mountain landscape. Using the latest formula, CDOW research biologist Dale Reed calculated that the San Juan Mountains may have only about 0.4 hares per hectare.

Alarmed by the new data, Reed says he counseled to delay the reintroduction until more data were in hand. "I said very firmly, 'It looks like we have marginal habitat,' " says Reed, who has since left the recovery team. But Kahn, Bryne, and others acknowledge that they chose to forge ahead. "We knew going into this that we had marginal prey base," says Tom Beck, a state biologist on the recovery team. "We always hedged our bets that they would have a more diverse diet."

The recovery team brought in the first lynx from Canada and Alaska in January, let them acclimatize for several days in holding pens in the San Juan Mountains, then began releasing them sporadically. But after four lynx starved to death within 6 weeks of their release, Reading and the other LWAT cochair, Brian Miller of the University of Denver, on 23 March wrote to Beck—CDOW's liaison to LWAT—recommending that the recovery team suspend further lynx releases until it had found locations with more prey. "[I]t will be a public relations nightmare to continue releases if conditions for success do not exist," Reading and Miller wrote. If good habitat cannot be found, they added, "we recommend abandoning the lynx program." Changing protocols, CDOW in April decided to delay the release of more lynx until later in the spring, opting to fatten up the captives and let them loose when alternative prey—red squirrels, marmots, and others—were coming out of their winter hibernation.

But as Reading and Miller had predicted, the starvation deaths sparked a furor. Outraged animal rights activists protested along with ranchers, who feared that the lynx may trigger new restrictions on land use. Environmentalists and conservation biologists also piled on. Carrying out a reintroduction, despite analyses suggesting that the habitat is unsuitable, is "shoddy science," charges Reed Noss, chief scientist at the Conservation Biology Institute in Corvallis, Oregon. "The program was rushed without adequate background research," he says.

Other wildlife biologists agree. According to Krebs, the hare scat analysis was done poorly. In electing not to clear the plots of scat and wait a year, he says, "they did it all wrong. ... You get snowshoe hare pellets from the last 10 years, and then you get 10 times the density" of a single year, he says. As for the CDOW's hopes that lynx would find alternative prey in winter, "that's just whistling in the dark," says Krebs. "They eat nothing but snowshoe hare. ... They are the ultimate in specialist carnivore."

Bryne agrees that it would have been better to have cleared the scat plots and wait a year, but he says the analyses were adjusted to account for overestimations based on old scat. Others contend that the scat sampling failed to zero in on the most promising areas to release lynx. "Hares exist in clumps, so instead of coming up with a 0.4 density in a general area, we need to identify where these pockets of prey are distributed," says biologist Gary Patton, FWS's representative on the recovery team. He and Bryne disagree with Noss's assertion that the science was shoddy. Besides, says Bryne, deaths in reintroductions are unavoidable. "I wish there were no mortalities," he says, "but that's not realistic."

Some experts call CDOW's strategy reasonable. "To restore a food chain and a population, it might be necessary to sacrifice individual animals. That's not sloppy science," says Paul Nickerson, chief of the FWS Northeast Endangered Species Division. Robert Ferris, a wildlife biologist with Defenders of Wildlife, agrees. "Anytime you have an opportunity to restore an endangered species to its habitat, you do it. These are animals that are destined for the fur trade; either we see them in coats or see them in Colorado."

All sides are watching nervously to see how the lynx fare this summer. If the lynx do well enough, state biologists would proceed to stage two, releasing another 40 to 50 lynx next spring. Although no one knows the magic number for a viable population, Patton thinks "you could have a very successful program out there and lose over half the animals." But the mounting criticism has taken its toll; if more than half the lynx starve to death this summer, the CDOW team has vowed to shutter the program. "That's as much a social and political protocol as it is a biological [one]," says Kahn.

The stakes are high if the animals survive. "What happens in Colorado will factor into future recovery plans for other states that want to reintroduce the lynx," says FWS lead lynx biologist Lori Nordstrom. A failure would have "broad implications," says Dennis Murray, a lynx researcher at the University of Idaho. "Other states might say it's not worth the headaches or politics." The Forest Service's Ruediger hopes the CDOW effort does not fall victim to unrealistic expectations. "There are all kinds of nuances that can go wrong, and you have to figure it out by trial and error. I don't know any other way to do it."

—KEITH KLOOR

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